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(12) (19) (CA) **Demande-Application**

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(72) KLUGE, Ehrhard, DE
(71) REXNORD KETTE GmbH & Co. KG, DE

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(54) **PROCEDE POUR PRODUIRE UN FEUILLARD LAMINE A CHAUD**

(54) **PROCESS FOR PRODUCING HOT ROLLED STRIP**

(57) Dans un procédé pour produire un feuillard d'acier inoxydable trempé, un acier contenant de 10 à 20 % de chrome, jusqu'à 3 % de nickel, jusqu'à 1,5 % de molybdène, jusqu'à 1 % de manganèse, jusqu'à 1 % de silicium, jusqu'à 0,6 % de titane, jusqu'à 0,1 % de carbone et jusqu'à 0,1 % d'azote, le reste se composant de fer et d'impuretés résultant de la fusion, est laminé à chaud, puis trempé directement à partir de la température de laminage. Pour ajuster la résistance, on peut laminer à froid le feuillard laminé à chaud jusqu'à obtention de l'épaisseur finale.

(57) In a process for producing a hardened stainless steel strip a steel containing 10 to 20% chromium, up to 3% nickel, up to 1.5% molybdenum, up to 1% manganese, up to 1% silicon, up to 0.6% titanium, up to 0.1% carbon and up to 0.1% nitrogen, balance iron and impurities arising from melting, is hot rolled and is then quenched directly from the rolling temperature. To adjust the strength the hot rolled strip may be cold rolled to its final thickness.

PROCESS FOR PRODUCING HOT ROLLED STRIP

ABSTRACT

In a process for producing a hardened stainless steel strip a steel containing 10 to 20% chromium, up to 3% nickel, up to 1.5% molybdenum, up to 1% manganese, up to 1% silicon, up to 0.6% titanium, up to 0.1% carbon and up to 0.1% nitrogen, balance iron and impurities arising from melting, is hot rolled and is then quenched directly from the rolling temperature. To adjust the strength the hot rolled strip may be cold rolled to its final thickness.

PROCESS FOR PRODUCING HOT ROLLED STRIP

FIELD OF THE INVENTION

The invention relates to a process for producing a hardened stainless strip of chromium steel.

BACKGROUND AND PRIOR ART

Stainless ferritic chromium steels are used in many ways as constructional steels on account of their high corrosion resistance, particularly to oxidising media, together with high strength and ductility, in view of their lower price compared with austenitic alloys: their corrosion resistance depends on their content of chromium and carbon. While the corrosion resistance improves with increase in chromium content, the presence of carbon leads to the formation of chromium-rich carbides, which separate out at the grain boundaries, where they lead to chromium impoverishment. In view of the above-mentioned connection between chromium content and corrosion resistance, this chromium impoverishment is associated with impairment of the corrosion resistance and leads to the ferritic steels being susceptible to a greater or less extent to intercrystalline corrosion, according to the carbon content. To counter this, efforts are made to keep the carbon content of ferritic steels as low as possible, or at least to bind the carbon stably by means of a carbide former, for example titanium. This, however, is associated with a considerable loss of ductility and corrosion resistance and also with the formation of titanium oxide, which impairs the surface condition and also the ductility and hot workability.

As long as the carbon content is not too low, the ferritic steels offer the possibility of obtaining a balance between high strength and adequate ductility by means of a heat treatment.

For this purpose German specification 39 36 072 describes a process in which a ferritic chromium steel containing 13 to 18% chromium and having a relatively low carbon content of at most 0.07% is first of all solution annealed after hot rolling

to strip and then quenched to a ferritic-martensitic two-phase structure in which the proportion of martensite is about 50%. In the quenched state the strip has a strength of at least 800 N/mm2 and a ductility which permits bending in the bend test with a small to zero bending radius without causing crack formation.

The solution annealing takes place at about 1000°C and is extraordinarily expensive, since the hot rolled strip, normally after cooling to room temperature, must first be brought to the annealing temperature and maintained there until the carbon has gone as completely as possible into solution. The solution annealing is therefore extremely expensive both in respect of the energy required to heat the strip up to the annealing temperature and on account of the high capital and operating costs for the annealing furnace.

Although it is in principle possible, using the known process, to bring hot rolled strip to a reasonable combination of strength and ductility without the need for cold rolling, the values of strength and ductility actually achieved in practice are subject to not inconsiderable fluctuations. To counter this, German specification 43 01 754 proposes a process in which the strip is first hot rolled to a certain oversize, and accordingly with a reserve of thickness. This makes a subsequent cold rolling necessary, by means of which both the desired final thickness of the strip and also its strength and ductility are adjusted.

So far as the thickness and mechanical properties of the hot and cold rolled strip are concerned, this process has proved extremely successful, but it does not eliminate the high financial burdens associated with the need for an anneal.

OBJECT OF THE INVENTION

The object of the invention is therefore to provide a process for producing hot rolled strip which requires far lower capital and operating costs without the quality of the finished strip suffering as a result.

SUMMARY OF THE INVENTION

This object is achieved in accordance with the invention by a process in which a steel containing

10 to 20%	chromium
up to 3%	nickel
up to 1.5%	molybdenum
up to 1%	manganese
up to 1%	silicon
up to 0.6%	titanium
up to 0.1%	carbon
up to 0.1%	nitrogen,

balance iron and impurities arising from melting, is hot rolled in the usual manner, e.g. using a rolling temperature of from 900 to 1100°C, and is then quenched directly from the rolling temperature.

The steel preferably contains at least 0.3% nickel, at least 0.1% molybdenum, at least 0.1% manganese, at least 0.1% silicon, at least 0.1% titanium, at least 0.01% carbon and at least 0.1% nitrogen, singly or in combination.

With regard to the desired strength and ductility, a steel containing

14 to 15%	chromium
1.4 to 2.0%	nickel
0.2 to 0.6%	molybdenum
0.02 to 0.04%	manganese
0.2 to 0.4%	silicon
0.25 to 0.35%	titanium
0.04 to 0.06%	carbon
0.02 to 0.05%	nitrogen

has been found particularly suitable.

In order to adjust the final strength and the thickness of the finished strip as exactly as possible, cold rolling of the quenched strip is advisable. This can be done by first determining the contents of carbide formers and carbon in the steel before the hot rolling, establishing a rolling oversize for the hot rolling dependent on the actual contents of carbide formers and/or carbon, quenching the strip after the hot rolling and then cold rolling it to the predetermined final thickness.

The oversize required in any particular case depends on the nature of the carbide former present and can be established by simple tests in which the connection between the actual content of carbide former or (though this is more difficult) the content of free carbon within the predetermined ranges and the thickness reduction by cold rolling required for the desired final strength is determined. A roughly linear relationship is found between the carbide former content and the thickness reduction required or the oversize corresponding thereto.

The thickness of the hot rolled strip includes the oversize resulting from the actual content of carbide formers or free carbon, which in the cold rolling to the final thickness brings with it the cold work hardening which is necessary to achieve the desired final strength.

Consequently in the process in accordance with the invention the oversize, and accordingly also the thickness reduction in the cold rolling, vary with the content of free carbon or of carbide formers within the predetermined ranges. The cold rolling only serves to eliminate the oversize and to adjust the strength to a constant value despite fluctuations in analysis.

In this way it is possible, by a specific adjustment of the oversize in the hot rolling, to create for every single charge starting conditions for the subsequent cold rolling to the final thickness which allow, through a measured cold work hardening, the desired final strength to be adjusted with great accuracy, or at least with a tolerance of ± 50 N/mm2.

If the steel contains 0.25 to 0.35% titanium, the rolling oversize in mm is calculated by the following equation:

$$OS = 6.5 \cdot Ti - 1.4$$

where OS represents the oversize in the hot rolling which corresponds to the required thickness reduction in the cold rolling.

The strip produced by the process in accordance with the invention has an extraordinarily fine-grained martinsitic-ferritic structure with isotropic properties and a strength of about 900 to 1000 N/mm2. It is particularly suitable for

further processing by stamping and bending. This results in high precision stamped and bent parts having sharp edges and high uniformity. This makes the strip which has been hot rolled, quenched and optionally also cold rolled in accordance with the invention particularly suitable for use as material for the production of chain links and link plates for roller, flyer and flat-top conveyor chains. Because no anneal is needed, the process in accordance with the invention is characterised by causing low environmental pollution, requiring little time and having high flexibility.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with reference to the accompanying drawings, in which:

Fig. 1 is a graph showing the increase in strength plotted against the thickness reduction in the cold rolling for steels of the composition used in the invention,

Fig. 2 shows the relationship between the titanium content of the finished steel and the required oversize in the hot rolling or the required thickness reduction in the corrective cold rolling.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

As can be seen from the diagram of Fig. 1, in the case of a steel having a composition used in the invention which has been hot rolled and heat treated in conventional manner, i.e. non-specifically, there is no connection between the thickness reduction on cold post-rolling and the increase in strength associated therewith. Thus without taking into account the actual titanium content within the permitted range of 0.25 to 0.35%, for example in the case of a thickness reduction of 0.3 mm in the cold rolling three different increases in strength were obtained, namely 80, 90 and 100 N/mm2, while an increase in strength of 100 N/mm2 can be obtained with thickness reductions of 0.3 to 0.7 mm.

In contrast to this, in the case of the steel in accordance with the invention, in the range of its titanium content of 0.25 to 0.35%, the same strength is always obtained if with the aid of the actual titanium content of the finished steel the thickness reduction in the cold rolling is adjusted on the basis of the graph in Fig. 2. The thickness reduction does not have to be kept to absolutely precisely; rather, fluctuations of ± 0,10 mm are possible without a significant change in strength resulting.

Hence by means of the process in accordance with the invention the same strength can be constantly achieved, independently of the titanium content within the limits in accordance with the invention of 0.25 to 0.35%. It follows from this that on melting the steel it is merely necessary to keep within these limits of composition: the actual titanium content, on the other hand, does not matter, since the desired constant final strength is adjusted in the cold rolling on the basis of the actual titanium content.

The embodiments of the invention, in which an exclusive property or privilege is claimed are defined as follows:

1. Process for producing a hardened stainless steel strip, wherein a steel containing:

10 to 20%	chromium
up to 3%	nickel
up to 1.5%	molybdenum
up to 1%	manganese
up to 1%	silicon
up to 0.6%	titanium
up to 0.1%	carbon
up to 0.1%	nitrogen,

balance iron and impurities arising from melting, is hot rolled and is then quenched directly from the rolling temperature.

2. Process as claimed in claim 1, wherein a steel containing at least 0.3% nickel, at least 0.1% molybdenum, at least 0.1% manganese, at least 0.1% silicon, at least 0.1% titanium, at least 0.01% carbon and at least 0.1% nitrogen is hot rolled.

3. Process as claimed in claim 1, wherein a steel containing:

14 to 15%	chromium
1.4 to 2.0%	nickel
0.2 to 0.6%	molybdenum
0.02 to 0.04%	manganese
0.2 to 0.4%	silicon
0.25 to 0.35%	titanium
0.04 to 0.06%	carbon
0.02 to 0.05%	nitrogen

is hot rolled.

4. Process as claimed in any one of claims 1 to 3, wherein before the hot rolling the contents of carbide formers and/or of free carbon in the steel are determined, a rolling oversize is established for the hot rolling in

dependence on the actual content of carbide formers and/or carbon and the hot rolled strip is quenched after the hot rolling to a ferritic-martensitic structure and cold rolled to the predetermined final thickness.

5. Process as claimed in claim 4, wherein the rolling oversize OS in mm in the hot rolling is established according to the equation:

$$OS = 6.5 \cdot Ti - 1.4.$$

6. Process as claimed in any of claims 1 to 5, wherein a hot rolling temperature of from 900 to 1100°C is used.

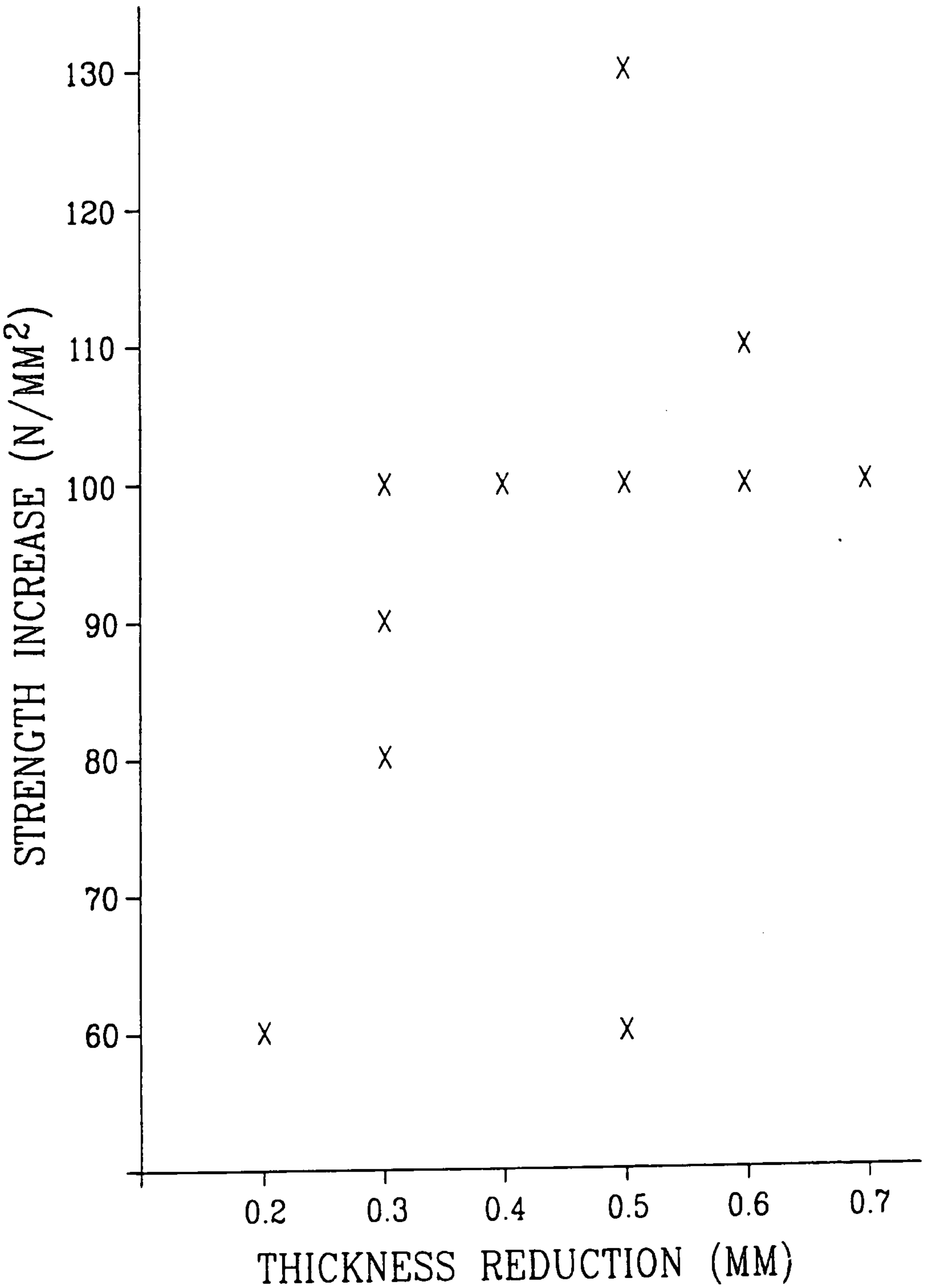
130
120
110
100
90
80
70
60
STRENGTH INCREASE (N/MM2)
0.2
0.3
0.4
0.5
0.6
0.7
THICKNESS REDUCTION (MM)

FIG. 1

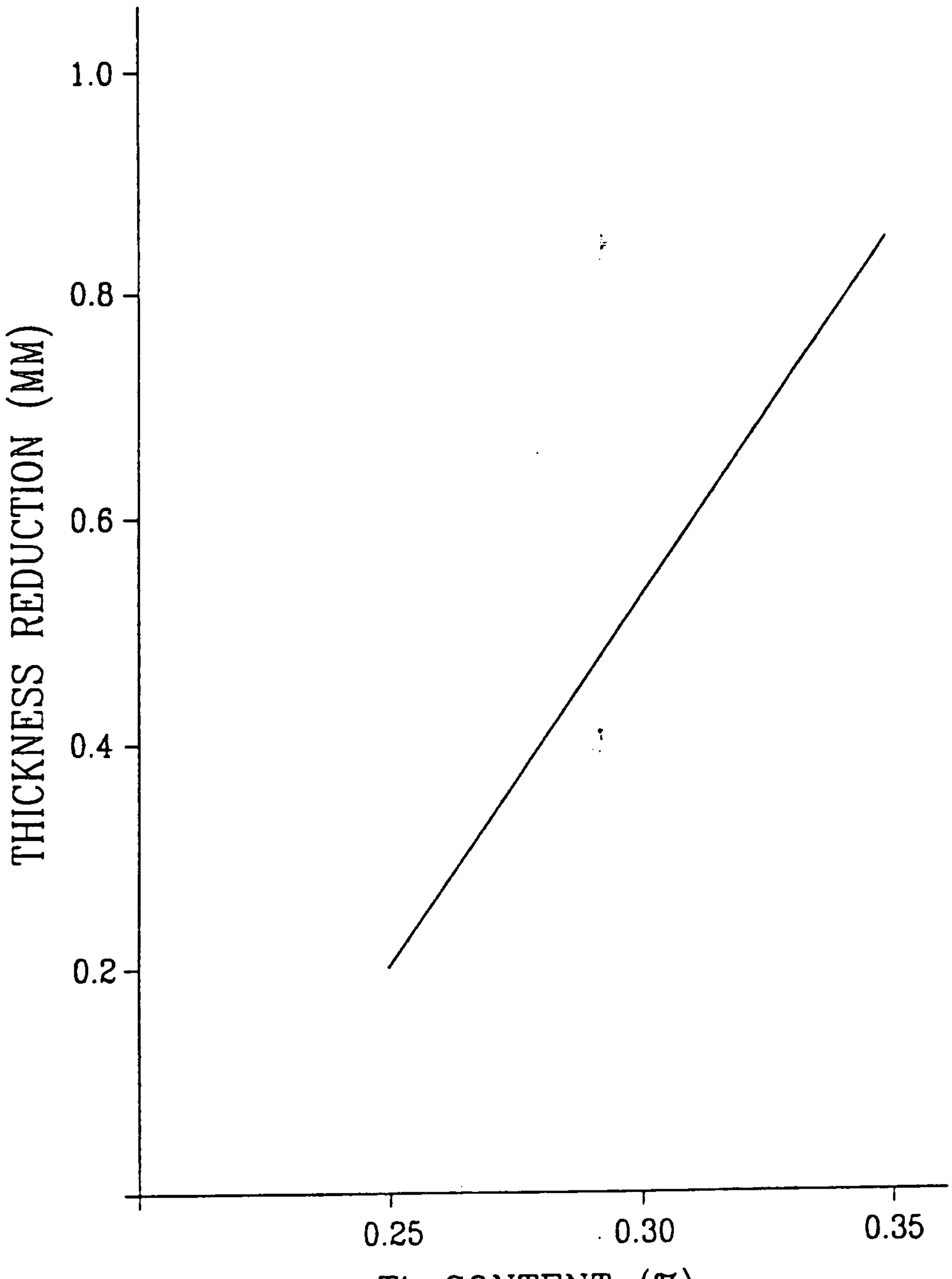

FIG. 2